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Statement of

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before the

Subcommittee on Space and Aeronautics
Committee on Science
House of Representatives

Mr. Chairman and Members of the Committee:

Thank for providing me the opportunity to discuss research priorities at NASA, and the status of NASA's Biological and Physical Research Enterprise.

In this testimony, I will provide a brief overview of the research conducted within the Office of Biological and Physical Research, highlight recent research accomplishments and plans for the upcoming Space Shuttle launch STS-107, and discuss the research now in progress on the International Space Station (ISS). I will describe two OBPR initiatives, and discuss the efforts of the Research Maximization and Prioritization (ReMap) Task Force of the NASA Advisory Council, which is chartered to form a review and assessment of the research priorities for the Office of Biological and Physical Research. I will discuss how NASA will use the results of this assessment to support the development of a research strategy to both fully utilize current International Space Station research capabilities, and provide a prioritized set of research requirements to be addressed in the event of research-driven enhancement to the ISS beyond the U.S. Core Complete milestone. Additionally, I will address NASA's efforts to develop a report on management of the ISS science program, which will include recommendations concerning the future management of ISS research utilization.

Overview

The Office of Biological and Physical Research uses the space environment as a laboratory to conduct basic and applied scientific, technological and commercial research, including the research required to support human exploration of space. OBPR has developed a strong research community which looks forward to expanding its knowledge and understanding in the physical sciences, biology and biomedicine, and to expanding the commercial use of space. With a community of more than 800 principal investigators we are a small, albeit vigorous program. Responses to our research solicitations are strong, and the private sector continues to show substantial interest in using the ISS. Our current efforts to clearly integrate and prioritize our research requirements will help us to reaffirm those areas in which we have the strongest contributions to make, and it will support our efforts to fully exploit the capabilities offered by the International Space Station.

The International Space Station has already made important contributions to research, and will continue to do so during the remaining assembly. As we look to the future, we are confident that ISS research will make even greater contributions in a number of different disciplines. Shuttle-based research, and reviews by the National Research Council have suggested a series of areas with high potential return:

In the area of Biomedical Research (Bioastronautics), researchers seek to understand and control the effects of the space environment on space travelers (e.g. muscle atrophy, bone loss and fluid shifts). The potential long-term benefits of this research include:

- developing methods to keep humans healthy in low-gravity environments for long periods—to enhance safety and crew productivity and to prepare for potential exploration; and
- advancing new fields of research in the treatment of diseases through new models for disease processes that are enabled by the microgravity environment in space.

In the area of Fundamental Space Biology, scientists study gravity's influence on the evolution, development, growth, and internal processes of plants and animals. Their results expand fundamental knowledge that may eventually benefit medical, agricultural, and other industries. The types of research planned for this field of science include:

- Increasing our knowledge of the fundamentals of biological evolution;
- Advancing our understanding of cell behavior; and
- Using plants as sources of food and oxygen for exploration;

In the area of Biotechnology, the microgravity environment allows researchers to investigate the molecular structure of major proteins and nucleic acids that have not been amenable to resolution on Earth. These structures contribute to drug development. In addition, the low-gravity environment provides the unique opportunity to grow three-dimensional tissues for research and to advance tissue-engineering technology. These activities can:

- Provide information to design new drugs to target specific proteins; and
- Support tissue culturing for use in disease research (cancerous tumors), tissue transplantation research (cartilage, bone, and eventually even organs), and the production of new pharmaceutical agents.

In the area of Combustion Research, scientists use microgravity to better understand complex combustion (burning) processes by carrying out experiments not possible on Earth due to gravity-driven convection. Since combustion is used to produce a large percentage of Earth's energy, even small improvements in efficiency can potentially have very large environmental and economic benefits. This can help to:

- Enhance fire detection and safety on Earth and in space;
- Improve control of combustion emissions and pollutants; and
- Enhance efficiency of industrial combustion processes.

In the area of Fluid Physics, the behavior of fluids fundamentally affects both living and non-living systems and is profoundly influenced by gravity. Researchers use gravity as an experimental variable to explain and model fluid behavior in natural and industrial systems on Earth and in space. These research efforts can contribute to:

- Improved spacecraft systems designs for safety, reliability and efficiency;
- Better understanding of soil behavior in earthquake conditions;
- Improved mathematical models for designing fluid handling systems for power plants, refineries and other industrial applications; and
- An improved understanding of the direct and indirect effects of gravity on complex systems such as biological organisms.

In the area of Fundamental Physics, scientists use microgravity to test fundamental theories of physics with degrees of accuracy that far exceed the capacity of earthbound science by experimentally probing systems under microgravity conditions not possible on Earth. These efforts allow us to:

- Challenge and expand theories of how matter organizes as it changes state;
- Test fundamental theories in physics with precision beyond the capacity of earthbound science; and
- Deepen our understanding of the physical phenomena in atomic physics.

In the area of Materials Science, researchers use microgravity by providing insight into processes that are masked in the presence of gravity to advance our understanding of the relationships among the structure, processing and properties of materials. This allows us to better design and manufacture advanced materials for application on Earth and in space. Research in this area focuses on:

- Advancing our understanding of processes for manufacturing semiconductors, metals, ceramics, polymers, and other materials;
- Determining the fundamental physical properties of molten metal, semiconductors, and other materials with precision impossible on Earth; and
- Advancing the understanding of fabrication processes for advanced biomaterials with properties of industrial and consumer product interest.

In the area of Space Product Development, commercial researcher affiliates currently invest about $50 million per year (cash and in-kind contributions) in research for the International Space Station. They are focused on:

- Improved drug development;
- Advanced combustion technologies;
- Sensor technologies; and
- Improved crop development.

Recent Research Accomplishments

OBPR's integrated program of ground-based and space-based (Space Station and Shuttle) research efforts have led to a series of important findings reported over the past year.

Flight research published in 2001 suggests our mind contains an internal model of gravity, and that this model may be very difficult or potentially even impossible to "unlearn."(Nature Neuroscience, 4, 693- 694, 2001). Astronauts quickly adjust to many of the challenges of orientation and movement associated with space flight, but the new results suggest there may be limits to this adaptability. Astronauts attempted to catch a "falling" object moving at different constant speeds. The test subjects proved unable to adjust to the fact that such objects do not "fall" faster and faster in space. The expectation that a "falling" object would accelerate proved impossible to unlearn over the course of the experiment. This experiment raises the possibility that the nervous system may contain a "hardwired" model of gravity. If confirmed, this would be a fundamental discovery that could influence medical treatments for people with damaged or impaired nervous systems. In addition, this finding has important implications for the design of safe and efficient environments and systems for human space flight.

OBPR investigators tested the drug midodrine as a remedy for the dizziness and fainting (called orthostatic intolerance) that astronauts sometimes experience when they attempt to stand immediately after returning to Earth from space. The drug proved effective in ground-based test subjects and will be tested in space. This research is important for ensuring the productivity of future explorers and the safety of future space travelers who may need to evacuate a returning spacecraft in an emergency.

In what may be a breakthrough for astronauts and osteoporosis victims alike, researchers were able to prevent bone loss using mild vibrations (Federation of American Societies for Experimental Biology Journal October 2001). Normally, rats lose bone when their hind limbs are suspended and no longer support the weight of the body. OBPR researchers were able to counteract this bone loss by exposing the rats to mild vibrations. This study opens the door to a new method for controlling the 1% per month loss of bone that astronauts experience in space. Clinical studies are planned to determine the usefulness of vibration for treating or preventing osteoporosis on Earth.

OBPR funded researchers created a gas cloud riddled with tiny whirlpools like those that cause "starquakes." (Science, Vol. 292 No. 5516, 20 April 2001). The researchers used an ultra-cold cloud of sodium gas and quantum effects to create a physical model of phenomena that take place deep inside distant stars. The importance of this kind of low temperature physics research was reinforced at the end of 2001 when Dr. Wolfgang Ketterle was awarded the Nobel Prize in Physics for his OBPR-funded work on Bose-Einstein Condensates. These experiments represent substantial milestones in physicists' quest to study quantum phenomena (physical phenomena that are ordinarily only observable at atomic scales) in macroscopic systems. This research could have far reaching implications for the future of information and communication technologies.

In biotechnology research, a research group at the Massachusetts Institute of Technology grew heart tissue with “significantly improved” structural and electrophysiological properties, using NASA bioreactor technology. (Journal of Physiology-Heart and Circulatory Physiology, Jan. 2001) Unlike tissue grown using more conventional technology, the tissue grown in the NASA bioreactor was actually made to beat like normal heart tissue. The NASA bioreactor allows researchers to grow tissues in the laboratory that much more faithfully reproduce the properties of natural tissues in the body. These tissues allow researchers to explore mechanisms of disease, and may ultimately improve processes for creating engineered tissue for use in treatment and transplant.

Twenty-four cell cultures, including colon, kidney, neuroendocrine, and ovarian cell cultures, were grown aboard the ISS in 2001. Bioreactor cell growth in microgravity permits cultivation of tissue cultures of sizes and quantities not possible on Earth. Cells may grow in low gravity in a manner akin to the way they grow in the human body, thereby allowing us to use space-grown tissues to support research in areas pertinent to human diseases.

StelSys (a joint venture of FVI and In Vitro Technologies) signed an agreement with NASA to explore commercial applications of bioreactor technology research specifically in areas related to biological systems.

Bristol-Myers Squibb and the Center for BioServe Space Technologies successfully demonstrated that production of antibiotics is substantially greater in microgravity than on the ground (Monorden at 200% greater; Actinomycin D at 75% greater). They are working to apply this research to ground-based processes.

The Center for Commercial Applications of Combustion in Space at the Colorado School of Mines established an agreement to work with Sulzer Orthopedics Biologics and other partners on the development of a ceramic-metal composite that may lead to more durable bone replacements. Industry is planning to invest over $6 million to perfect these materials.

OBPR’s Center for Biophysical Sciences and Engineering (CBSE) formed an exclusive partnership with Athersys, Inc., a premier genomics company. Genomics is the science of describing the proteins that are encoded by the genes in our DNA. CBSE has developed a world-class capability to determine the exact shapes and structures of proteins through the process of protein crystallography. Precise information on the protein structure is critical to the design of highly specific and effective new drugs, and the microgravity environment of space allows the growth of crystals with greater purity and size than on the ground.

STS-107

In July 2002, NASA will launch STS-107, a research-dedicated Space Shuttle mission. The scientific and commercial research conducted on STS-107 will advance our knowledge in medicine, fundamental biology, fluid physics, materials research, and combustion science. STS-107 is comparable to the multidisciplinary Spacelab missions flown during the 1980s and ’90s. In most cases, STS-107 experiments will build upon the highly successful Spacelab results, as well as serve as a prelude to the long-duration investigations planned aboard ISS.

STS-107 will be carried out aboard Space Shuttle Columbia. Columbia will carry the first flight of the SPACEHAB research double module, which provides the lab space where the flight crew will work. Columbia will also carry the FREESTAR payload, which supports a host of experiments, which utilize the space environment in the cargo bay.

NASA’s Office of Biological and Physical Research is the primary sponsor for the STS-107 mission. It is responsible for 30 investigations in Bioastronautics Research (12, including an investigation of the risk of getting kidney stones in space), Fundamental Space Biology (6, including an investigation of bacteria physiology and virulence), Physical Sciences (7, including a soil mechanics experiment that addresses issues in earthquake engineering), and Space Product Development (5, including a water mist experiment to enhance fire-fighting technologies). Additionally STS-107 will include education activities (2) and experiments for NASA’s Office of Earth Science (3), an ISS technology development experiment, European Space Agency experiments (6), and a number of commercial and other experiments sponsored by SPACEHAB, the U.S. Air Force, and other parties.

Research Aboard the ISS

The International Space Station represents a major leap in on-orbit capabilities for research. Researchers previously restricted to one or two 14-16 day space-based research opportunities per year are now beginning to utilize the ISS as a continuously operating space-based laboratory. The OBPR looks forward to the opportunity to continue to build upon the strong results of our ground-based, Shuttle and ISS research as the ISS continues to grow in capability.

ISS state-of-the-art U.S. research facilities consist of science discipline dedicated racks (referred to as Research Facilities), EXPRESS racks, and multiple Experiment Modules. The Research Facilities support a variety of experiments in one or more related scientific disciplines. The multi-purpose EXPRESS rack provides simple, standard interfaces to accommodate drawer-level, locker, and small-module payloads. All facilities are potentially available to support the entire research community in the U.S. and with our partners.

ISS research outfitting began with the Expedition 1 delivery of the Human Research Facility in March 2001. NASA delivered two research equipment racks (EXPRESS racks 1 and 2) on Expedition 2 in April 2001, and an additional two racks (EXPRESS racks 4 and 5) on Expedition 3 in August. The Agency is on-track to deliver another five research racks by the end of 2002.

We are currently conducting Expedition 4 on ISS. In each of the Expeditions, research experiments have been ongoing in scientific disciplines such as biology, bioastronautics, crystal growth, commercial research and science educational activities. In planning early research, OBPR established research increments during each of the expeditions, with a particular theme or focus. The Expedition 1 crew initiated several U.S. research activities including crew Earth observations, macromolecular crystal growth (structural biology), vibration control experiments, and human research baseline data collection and an Educational activity called SEEDS (Space Exposed Experiment Developed for Students) that was very successful in teaching students about plant biology, the microgravity environment, and scientific reasoning.

During Expedition 2, 18 experiments were conducted. The focus of this Expedition was on biomedical research, and included studies of biological effects of space radiation, bone loss, spinal cord response during space flight, and interpersonal influences on crew member and crew-ground interactions. Other experiments included plant germination and growth; Earth observations; and macromolecular crystal growth experiments.

Research on Expedition 3 included eight new and ten continuing experiments. Expedition 3 experiments include investigation of the mechanism of space flight-induced orthostatic intolerance, which has symptoms such as dizziness, fainting, lightheadedness, palpitations, tremulousness, and poor concentration. Also included in Expedition 3 was a study of heart and lung function in space and as affected by Extravehicular Activities (EVA), a study of the risk factors associated with kidney stone formation during and after space flight, an investigation of new techniques for structural biology in space, and a study of materials passively exposed to the space environment around the ISS to better define changes in material properties and on-orbit material degradation trends.

Expedition 4 began in November 2001 and will conclude in June 2002. New investigations on Expedition 4 include testing of a new plant growth apparatus, commercial research on zeolite crystals, a Bioastronautics study of EVA, and academic and commercial research on macromolecular crystal growth. In addition to the 14 new experiments, there are 15 experiments that will continue throughout both Expeditions 4 and 5. The Expedition 4 crew will flight test a drug to control dizziness and the inability to stand on return to Earth, and they will conduct research addressing challenges to the immune system and other effects of space travel. Expedition 4 includes the debut of the Education Payload Operations, an ongoing ISS education program as well as two other activities that engage students in science research.

During the upcoming Expedition 5, three new facility elements will be added: ARCTIC 2 (a freezer for biological specimens), EXPRESS rack 3 and the Microgravity Sciences Glovebox, which is shared between the Physical Sciences and Commercial communities. On average, there will be 27 experiments running throughout Expedition 5.

The ISS is already providing important results, which will continue to be forthcoming as data are collected and analyzed. This is typically a lengthy process requiring a year or more as researchers evaluate data, write their papers, and submit them for review and publication. Below are some of the most interesting early results:

> A series of recent physics investigations on the ISS use tiny particles suspended in a fluid (colloids) to model the behavior of atoms and molecules. These model systems allow researchers to observe the process by which matter spontaneously organizes itself. The results of this research have not yet been published, but the investigators report that they have observed phenomena, which they had not been able to create in laboratories on Earth. In terms of basic research, these colloid investigations support a deeper understanding of self-assembling processes in general. In terms of potential long-term applications, the research has its most direct applicability to the design of future switches, filters and displays for use in fiber optic and photonics technologies.
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> The Phantom Torso research onboard the ISS is indicating that the measured dose of galactic cosmic rays to the skin is an accurate (within 15%) estimate of the dosage to internal organs, while the skin dose of trapped protons over- estimates the dose to internal organs. [Badhwar GD., Radiat Res. 2002 Jan;157(1):69-75; Badhwar GD, et al., Radiat Res. 2002 Jan;157(1):76-91.] This is important for understanding risk to astronauts and in designing shielding or other countermeasures.
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> Preliminary results indicate that spinal cord reflexes (spinal cord excitability) reduce rapidly upon exposure to weightlessness, as expected. Unexpectedly, these reflexes appear to recover several months into a mission. Exploring the mechanisms behind the recovery process may lead to an improved understanding of central nervous system function on Earth, as well as improved protective measures for future space travelers.

New Initiatives

In support of OBPR strategic goals, and within the FY 2003 budget request, OBPR has included two new initiatives: $11.2M ($197.2M over five years) for "Generations;" and $10.1M ($106.5M over five years) for "Space Radiation."

The Generations effort will study the adaptation of organisms to the space environment over several generations and investigate the capacity of terrestrial life to evolve in space. The project will employ ground-based research, the ISS, and free-flyer platforms flying in different orbits, including a high-Earth orbit beyond the Van Allen radiation belts. These multiple platforms will enable researchers to study the varying effects of the space environment on biological systems and processes in order to better understand the mechanisms of evolution. It will add to our fundamental knowledge, and may enable the development of countermeasures and life support technologies for future space missions. The research planned for this initiative complements the research currently planned for ISS, in that the science will maximize early ISS research capability. It focuses on the genomic mechanisms involved in the process of adaptation to space, and the early ISS hardware readily supports these kinds of studies.

On an interdisciplinary basis, Bioastronautics, Physical Sciences, and the Fundamental Space Biology Programs will accelerate efforts to develop the knowledge, tools, and techniques required to address space radiation health issues. The Space Radiation initiative was prompted by the need for increased understanding of the effects of the radiation environmenton biological tissue in Low Earth Orbit (LEO) and beyond, and will support efforts to reduce the uncertainties associated with predicting risks to astronauts exposed to radiation during space flight. This ground-based research initiative will generate knowledge, assess health risks, and develop radiation shielding tools, strategies and countermeasures that can be employed aboard ISS and future space missions.

Research Maximization and Prioritization (ReMaP)

The OBPR is currently engaged in an effort to clearly integrate and prioritize its research requirements. This will help us to reaffirm those areas in which we have the potential to make the strongest research contributions—those contributions that will most impact fundamental scientific knowledge and understanding, or most advance the use of the space environment for commercial endeavors. It will support our efforts to fully exploit the capabilities currently offered by the International Space Station. It will inform NASA in terms of establishing a prioritized set of research requirements to be addressed as the Agency proceeds to the U.S. Core Complete milestone, and as it considers the possible evolution of the ISS beyond that milestone.

Clearly, we have not been without priorities prior to this point. The OBPR has, in the past, engaged in a long-running effort to maximize return from the ISS. Plans for ISS utilization have been phased to match ISS development for several years. We have continued to align the schedule and capabilities planned for the ISS with advice from our user community, policy guidance from the Administration, and budget authority from the Congress.

Like the other research Enterprises within NASA, OBPR's primary source of strategic advice on priorities for ISS research has been the National Research Council of the National Academies of Sciences. NRC reports have reviewed results of past flight experiments and identified those fields of scientific research which can be most fruitfully pursued on the ISS. They have proven invaluable in setting the direction of research within our scientific disciplines. However, the NRC has generally not prioritized research across multiple scientific disciplines.

Given the very diverse multidisciplinary nature of planned ISS research, prioritizing across disciplines has presented NASA and the OBPR with a significant challenge. To date, OBPR's approach has been to maintain resource allocations among Physical Science Research, Life Sciences Research, and Commercially funded research. Each major category of research has historically had about a 30% allocation of available ISS resources.

In the current environment of ISS schedule and cost uncertainty, and consistent with recommendations from our advisory committees, we have elected to step back and assess our research priorities with an eye towards identifying those efforts which are likely to realize the greatest progress and impact. Our goal is to build the most productive program that we can within the President's budget plan, one that is affordable, that fully utilizes the capabilities offered by the ISS, and that establishes a clear set of prioritized requirements that will serve to guide the Agency as it proceeds with ISS development.

The first, and most crucial step in this process is underway. We have assembled a team of experts—the ReMaP Task Force—to help us assess our research priorities. They are working throughout the course of April, May and June. We have asked the committee to begin by setting aside the details of the budget and resources trades, in order to focus first and foremost on prioritizing OBPR research content in terms of where they believe the potential for greatest progress and impact might be made. They are doing this in light of the vast body of external advisory committee recommendations that currently exist for each of the major OBPR scientific disciplines. Many of the Task Force members participated in the writing of these earlier recommendations.

Once this prioritized content is known, we will work with the Task Force to assess the extent to which we can address the priorities, given the current budget, and current and planned ISS capabilities. We will learn where the gaps lie, in terms of our abilities to meet the priorities.

The results of this assessment will guide us as we develop our OBPR research plan, our ISS utilization plan, and the corresponding FY 2004 budget request. Additionally, it will guide NASA's Office of Space Flight, as it evaluates options for potential ISS assembly enhancements beyond core complete.

In summary, the process that we are currently engaged in, with the help of the ReMaP Task force, will support us in developing an FY 2004 budget request that outlines an integrated research program that maximizes our science return in the near-term, and lays the groundwork for the future.

ISS Research Utilization

NASA has received congressional direction concerning the management of ISS Research. The FY 2000 NASA Authorization Act called upon NASA to enter into an agreement with an NGO for the management of ISS research. The FY 2001 and FY 2002 VA-HUD-IA Appropriations Acts include statutory limitations against NASA's "finalizing an agreement…between NASA and a non-governmental organization;" the accompanying FY 2002 VA-HUD-Independent Agencies Conference Report indicates that the "conferees look forward to receiving a comprehensive proposal for managing the ISS science program at which time it will re-evaluate the foregoing prohibition."

NASA has, in fact, engaged both the external community and the internal NASA workforce to evaluate possible options for managing ISS utilization. Since the 1999 timeframe, three external studies and one internal study have been completed. The reports have focused on the establishment of a Non-Governmental Organization to manage ISS research utilization.

Beginning with the FY 2002 Budget Blueprint, several changes have occurred:

1. Decreasing research funds and limited crew availability have driven reductions in the research planned during the assembly period.
2. The ISS Management and Cost Evaluation (IMCE) Task Force was instituted to perform an independent external review and assessment of cost and budget and provide recommendations on how to ensure that the ISS can provide maximum benefit to the U.S. taxpayers and the international partners within the Administration's budget request.
3. In response to IMCE and NASA Advisory Council (NAC) recommendations, the ReMaP Task Force has been engaged to support NASA's efforts to prioritize the research content within the OBPR.
4. The Agency has responded to the President's Management Agenda with focused attention on determining "inherently governmental functions" and what that might imply for the Agency's yearly Federal Acquisition Inventory Reform (FAIR) Act submittal.

Given the significant changes that have occurred over the past year, NASA has elected to engage an internal NASA ISS Utilization Concept Development Team, which will work over the course of this summer to further examine options for the management of ISS utilization. The team will, building upon the work done to date, characterize the current ISS utilization processes, organizational interfaces and management framework; identify the inherently governmental functions within the ISS utilization processes, and assess the advantages and disadvantages of various management approaches to ISS utilization. Additionally, the team will provide recommendations concerning NASA process and/or organization change or reform, and assess the implications for workforce transition and/or skill mix rebalancing.

By September 2002, NASA will use the products of the ReMaP effort and the ISS Utilization Concept Development Team to formulate a report to Congress on the management of ISS science utilization. The report will summarize NASA's evaluation of the various options for management of ISS utilization and provide a recommendation for the future management of ISS research.

Conclusion

This is a very dynamic time for the Office of Biological and Physical Research. Yes, we have some clear challenges and changes ahead, including establishing an integrated set of priorities and determining the corresponding future course for our scientific program. We must establish our long-term strategy for managing ISS research utilization. But these tasks are manageable. They can be accomplished, and I am convinced that we will be the better for it.

With challenge and change comes opportunity. And the opportunity afforded the research community by the International Space Station is, indeed, unparalleled. The ISS represents a quantum leap in our capability to conduct space-based research. It promises unique research facilities, unprecedented on-orbit Station resources, and important crew interactions. And with our early utilization of the ISS, we are just beginning to get a glimpse of the tremendous results that this new era in space-based capability will provide.

Let us consider, in summary, what research on the ISS is all about. It is about having the capability to perform multiple repetitions of experiments when they hint at new discoveries, and the ability to modify and re-fly the most promising of these experiments. It's about studying multiple generations of several types of organisms in space to learn about development, growth and aging in the absence of gravity. It's about using finely controlled experiment environments to test fundamental scientific theories with a precision that is unparalleled on the ground. It's about having the long-term capability to address the full spectrum of NASA's space-based research portfolio. And it's about generating new knowledge and training the next generation of scientists, engineers and technologists.

We know the return from our research will be measured not only by scientific results, publications and the generation of new knowledge. It will also create the inspiration and the foundation for the next generation of explorers. These are the ones who will lead us into realms that we cannot even imagine.